APPLE BITTER-ROT AND ITS CONTROL

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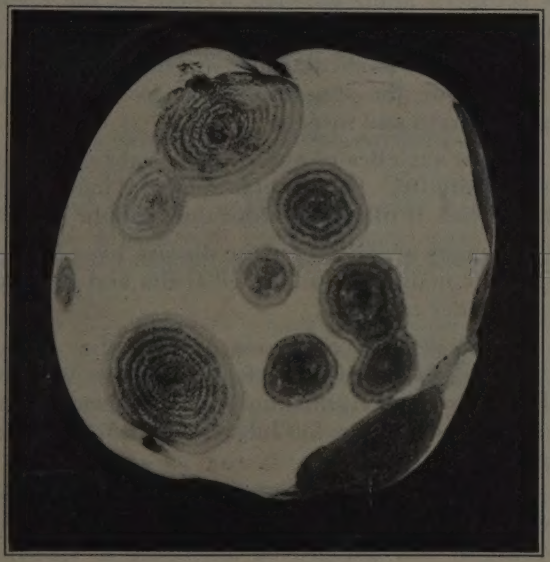

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APPLE BITTER-ROT is a serious disease in the southern apple-growing sections of the United States.

Hot weather, particularly if moist, favors the development of the disease, which is disseminated largely by rain and insects.

Different varieties of apples show varying degrees of susceptibility. In new plantings, the more resistant varieties, if otherwise desirable, should be used.

The fungus which causes the disease lives through the winter mainly in mummied fruits and in bitter-rot and other cankers.

Under ordinary conditions and in the average orchard, spraying with Bordeaux mixture will control the disease. Applications of the spray should be made about June 15, July 1, July 15 to 20, and August 1 to 5.

In orchards, especially those of the Middle West, in which the disease has been severe through a term of years or has not proved amenable to spraying, the overwintering sources of infection should be removed.

APPLE BITTER-ROT AND ITS CONTROL.

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DESTRUCTIVENESS OF APPLE BITTER-ROT.

BITTER-ROT OF APPLES (caused by the fungus *Glomerella cingulata*) has long been recognized by orchardists of the southern United States as a disease of great destructiveness, especially in warm, moist seasons, and as one which it is more than ordinarily difficult to control.

In seasons when the rainfall is excessive and the temperature is uniformly high, orchards in which sources of infection are present may lose the entire crop because of bitter-rot. In occasional orchards the sources of infection are so abundant that only a few days of moist, hot weather will bring about the total destruction of the crop. Generally the disease is not very destructive in cool seasons, even though plenty of moisture be present.

The disease may appear from about the middle of June until the early part of September, i. e., at any time during the warmer part of the season. Most commonly, few infected apples are to be found until after the first of July, but the grower should not take the chance of waiting for the appearance of the disease before inaugurating control measures.

Owing to the unevenness of outbreaks of the disease and the part which weather conditions play, it is impossible even to approximate the annual financial loss occasioned by bitter-rot. To the grower, the money loss is increased by the fact that after he has spent time and money in preventing damage by the codling moth, and perhaps by scab or blotch, bitter-rot may appear on previously clean, smooth fruits well on their way to maturity and eventually destroy them.

Typically bitter-rot is a disease of southern apple-growing sections, being of little importance where it is occasionally found in the North.

It is a very serious disease in Maryland, Virginia, West Virginia, southern Indiana, southern Missouri, and to the southward of those States. It reaches its highest point of destructiveness, however, in the more western of the sections mentioned above, being especially serious in Arkansas, southern Missouri, and southern Illinois.

DESCRIPTION.

The first appearance of the disease is indicated by the presence of small light-brown, sometimes almost colorless, spots or blisterlike places just beneath the skin of the apple. Under favorable conditions and where only a few are on an apple these infected areas rapidly increase in size, often attaining a diameter of an inch in four or five days. Beneath these spots are the rotted tissues of the

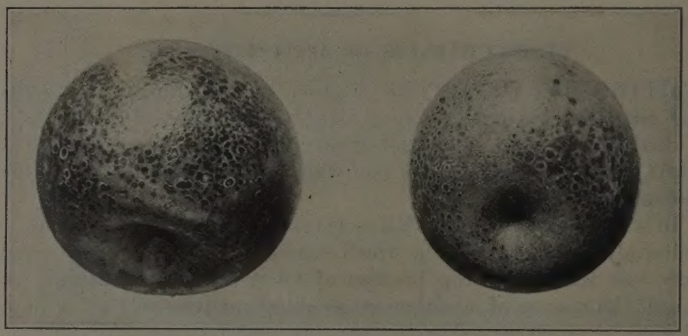

FIG. 1.—Apples with a peppered appearance, due to many infections with bitter-rot. These small blisterlike spots were caused by spores coming directly from a bitter-rot canker on a limb above.

flesh, which extend through to the core, the rotted portion being in the shape of a cone, the base of which is at the surface of the apple and the apex at the core. The rotted flesh often, though not always, has a bitter taste. At first it is watery, in which respect it differs markedly from black-rot (due to *Sphaeropsis malorum*), the only other rot with which bitter-rot is likely to be confused. Later, the rotted portion may increase in size until the entire apple is involved, or it may fail to develop further and become so thoroughly dried that nothing is left but a cone-shaped cavity covered by blackened, dead, papery skin.

In most cases the tissues about the rotted portion are not discolored by the disease, but yellow apples, especially those of the Yellow Newtown variety, sometimes show a purplish red discoloration of the skin about the affected spot.

When the infections on each apple are many (and there may be as many as a thousand), usually not more than a half dozen of the

spots will develop beyond an eighth of an inch in diameter. Often none will develop beyond a sixteenth of an inch in diameter, when the apples will present a peculiar peppered appearance (fig. 1).

After the spots have attained a diameter of about half an inch they become sunken because of the shrinkage of the underlying tissues. About this time, also, the acervuli, or masses of conidia, which are the reproductive bodies of the fungus, begin to appear. These occur in concentric rings and are in the nature of pustules, which upon breaking through the skin appear as rings of small beads, pink at first, later becoming dark brown or black. (See the illustration on the title-page.)

CAUSE OF THE DISEASE.

The fungus [1] which causes apple bitter-rot grows as an interwoven threadlike mass, or mycelium, through the tissues of the apple, between and into the cells, killing the cells themselves and breaking up the tissues. The concentric rings of pink pustules, or acervuli, which later appear on the surface of the rotted spot, are masses of the spores of the fungus, by means of which the disease is transmitted to other fruits. When weather conditions are favorable, a spore which finds lodgment on an apple may germinate and send its germ tube into the flesh, thus starting a rotten spot unless the apple has been covered previously with Bordeaux mixture, in which case the germ tube dies without penetrating the skin of the apple. The fungus also produces a fruiting body, in which spores are produced in small sacs, or asci, within a tiny hard, black, more or less spherical case, or perithecium. This form of fruiting body is often referred to as the "perfect" stage of the fungus, but is not of so great importance from a disease standpoint as the pustules (acervuli).

MEANS OF DISSEMINATING BITTER-ROT.

It is through the agency of spores, especially those from the acervuli (imperfect stage), that the disease is transmitted to sound apples. The spore masses, or acervuli, when newly formed are pink and mucilaginous or thinly gelatinous. Later, however, upon drying they become dark colored and of a hard, horny consistency. Their gelatinous nature when wet and their horny consistency when dry prevent their dissemination by wind, but raindrops can spatter them about, especially upon the fruit located below them. Excessive moisture also can cause the spore masses to trickle or drip down from infected fruits and alight upon sound ones. Birds probably play some part in the dissemination of spores, but a much more important rôle is played by insects, more especially flies. It

[1] *Glomerella cingulata* (Stoneman) Spaulding and Von Schrenk.

has been demonstrated repeatedly that flies alighting upon infected apples come in contact with the mucilaginous spore masses, some of which adhering to them may be carried to and deposited upon sound fruit.

RELATIVE SUSCEPTIBILITY OF APPLE VARIETIES.

Most varieties of apples are susceptible to bitter-rot, at least to some extent, but they differ considerably in this respect, as Table I shows. The susceptibility or resistance of a given variety will often vary considerably according to the section of the country in which it is grown and its location with respect to highly susceptible or highly resistant varieties. Weather conditions also constitute an important factor. During prolonged periods of hot, moist weather, the fungus is able to attack successfully varieties which normally are rather resistant.

When new plantings of the apple are made in sections in which bitter-rot is prevalent, preference should be given to the more resistant varieties, provided they are otherwise desirable.

TABLE I.—*Relative susceptibility of apple varieties to bitter-rot.*

Very susceptible:	Moderately susceptible—Continued.	Rather resistant—Contd.
Corfu.	Limbertwig.	Baldwin.
Fallawater.	Missouri.	Delicious.
Gibbs.	Nero.	Maiden Blush.
Givens.	Northern Spy.	Rome Beauty.
Highfill.	Northwestern.	Stayman Winesap.
Huntsman.	Oliver.	York Imperial.
Lansingburg.	Paradise.	Slightly susceptible or resistant:
Smokehouse.	Pilot.	Akin.
Willow.	Smith.	Arkansas Black.
Yellow Newtown.	Stark.	Bismarck.
Moderately susceptible:	Winter Queen.	Langford.
Ben Davis.	York Stripe.	Ralls.
Gano.	Rather resistant:	Salome.
Grimes.	Arkansas.	Winesap.
Jonathan.		

SOURCES OF INFECTION.

Knowledge as to the places in which the causal fungus is able to live through the dormant season and to develop and reinfect the fruit during the following summer is of importance in determining measures for the control of the disease. If it were possible to eliminate all such places, control would be obtained without further effort.

The fungus causing apple bitter-rot usually lives through the winter in mummied apples, in bitter-rot cankers or cankers in which this fungus is the causal organism, and in cankers caused by other agencies.

Mummied fruits constitute the most common source of infection throughout the bitter-rot section of the United States. A mummied fruit is one which during the previous season has been affected with the disease and has remained on the tree or on the ground in a more or less shriveled condition. In such fruits the fungus is able to exist throughout the winter, producing spores when the hot season re-

FIG. 2.—An apple affected with bitter-rot and, just above it, a mummied apple of the preceding season. Spores washed down from the mummy have infected the previously sound apple.

turns. The spores from mummies hanging in the tree are spattered by the rain upon the current season's fruits, thus infecting them with the disease (fig. 2). Infection from mummies on the ground takes place through the medium of flies or by actual contact between the mummied fruits and the apples on low-hanging limbs.

The bitter-rot canker is a common source of infection in the western part of the bitter-rot section, but is rare in the eastern part. The

canker (fig. 3) consists of a black sunken portion of bark, usually somewhat oval in outline, beneath which the wood is dry and dead. The dead bark and cambium adhere rather firmly to the wood, and in older cankers more or less complete cracks, or fissures, parallel to the edges of the cankers give a zoned effect to the dead bark. Often the canker is surrounded by a layer of callus which prevents its further extension and eventually heals over the old lesion. Cankers usually are not found on branches which are less

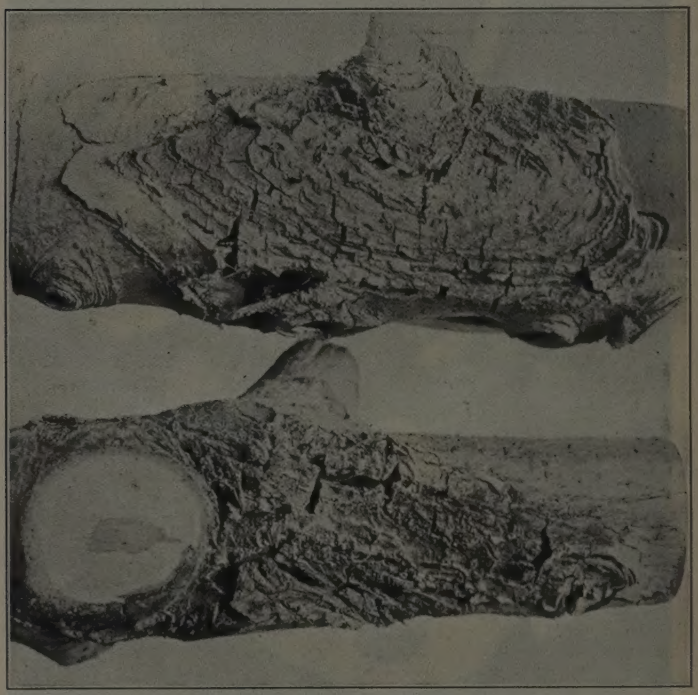

FIG. 3.—Bitter-rot cankers which were located directly above clumps of rotted fruits. These cankers were producing spores in immense numbers.

than two years of age. In cankers the fungus may live one or more years, producing each season immense quantities of spores, which may be carried to sound fruits. The crop of a tree in which there are many bitter-rot cankers during a hot, moist season is doomed to destruction despite frequent and thorough sprayings.

The susceptibility of different varieties of the apple to this phase of the disease varies to a considerable degree. Among commercial varieties the Givens is very susceptible, while the Jonathan, Mis-

souri, Ben Davis, and Grimes, in the order named, are moderately susceptible. The York Imperial and the Yellow Newtown are practically immune.

The fungus may live through the winter in cankers caused by agencies other than bitter-rot and on dead branches and the tips of fruit spurs. Where the fungus exists in these places and, in addition, mummies and bitter-rot cankers are present, during seasons favorable to bitter-rot any control measures which do not take into consideration the elimination of sources of infection will be inefficient, if not entirely useless.

Infected fruits of the current year also are dangerous sources of infection, since from them sound apples may become infected. It is by them that the disease is spread during the growing season, after it has gained a start from spores produced in the places in which the fungus has passed the winter; therefore, in the control of the disease it is of prime importance to prevent any infections from occurring or, if they do occur, to remove, if practicable, the infected fruits, together with the mummies or cankers from which the infection came, before they can act as infection carriers. The fungus may infect other hosts besides the apple and sometimes occurs on apple leaves, but these are of little importance from the standpoint of disease control.

In the Eastern States mummies are usually the places where the fungus passes the winter, but in the Middle West, especially in badly infected orchards, limb cankers caused by the bitter-rot fungus and by other agencies often surpass mummies in importance.

REMEDIAL MEASURES.

SPRAYING.

Under ordinary conditions and in the average orchard in bitter-rot sections (one in which the disease has not annually destroyed almost the entire crop), three or four thorough sprayings with Bordeaux mixture will afford adequate control. Spraying for the control of bitter-rot, however, must be done with special care, and at least one application should be made before the disease appears.

Bordeaux mixture composed of 4 pounds of bluestone (copper sulphate) and 4 pounds of stone lime to 50 gallons of water should be applied (1) about June 15, (2) two weeks later (about July 1), (3) July 15 to 20, and (4) August 1 to 5.

In cool seasons the intervals between applications may be increased about one week and only three applications made.

For the control of insect pests arsenate of lead at the rate of 2 pounds of paste or 1 pound of powder to every 50 gallons of the Bordeaux mixture may be added in each application, and it certainly should not be omitted from the second one.

In the application of sprays for the control of bitter-rot it should be borne in mind that the object is to cover the fruit completely. In order to do this properly, Vermorel or disk-type nozzles with small openings should be used under a pressure sufficient to give a fine mistlike spray. The best results are obtained by the use of a power sprayer with which a pressure of 200 pounds can be maintained. By manipulation of the spray rods at different angles the spray should be made to strike all parts of the fruit.

Lime-sulphur solution, though efficient in the control of apple scab, will not control bitter-rot.

REMOVAL OF SOURCES OF INFECTION.

In the case of some orchards, especially many of those in the Middle West in which the disease has been very destructive for a term of years, often in spite of frequent and thorough spraying, it will be necessary to remove as many as possible of the overwintering sources of infection, besides following out the spray schedule just mentioned. In some of these orchards the disease has gained such a foothold that at the very first outbreak nearly every apple will show an average of from 50 to 100 points of infection from overwintering sources. Spraying alone under such conditions will act as a preventive to some extent but will not give adequate control. With such abundant sources of infection, control by spraying could be accomplished only by keeping the entire surface of every apple covered with Bordeaux mixture throughout the infection period, which is obviously impossible. In many orchards there will be only a few trees, or perhaps a single section of the orchard, in which the disease is not amenable to control by spraying. Often from such trees the entire orchard will become infected; therefore, special attention should be given to the removal of overwintering sources of infection from them.

The best time for the removal of mummies hanging on the trees is during the dormant season, when they can be poked off with a stick or pulled off by means of a pole with a wire hook attached. If, however, care be taken at picking time to remove the infected as well as the sound fruit there will be few mummies to remove later. Those on the ground can be removed at picking time or at any time before the next summer, or if not numerous they may be turned under when spring cultivation is commenced. In many orchards, such as those planted on rocky hillsides, the removal of mummies on the ground is impracticable; however, they are not nearly so important as those hanging on the trees.

The removal of cankers and dead wood can be carried on to the best advantage in connection with the spring pruning. It is not so difficult an operation as many growers seem to think and is usually not nearly so expensive as a single application of Bordeaux mixture. It should

be remembered that the removal of the cankers and dead wood helps to prolong the lives of the trees and is an efficient measure in the control of other diseases, especially black-rot or ring-rot and leaf-spot.

In most cases bitter-rot cankers as well as cankers caused by other agencies will be found on relatively small limbs, and usually they can be removed by simply sawing or cutting off the limbs.

Cankers on large limbs may be removed by means of a sharp knife or, better, a carpenter's gouge. The cut should be made well into the living bark and the margins evenly trimmed unless a callus layer has already begun to form. It is best to sterilize the cut places and tools at every operation with a mercuric-chlorid solution (1 to 1,000 strength). Mercuric chlorid is procurable in tablet form at all drug stores, and directions are given on the bottles for making a 1 to 1,000 solution. After a few days the exposed wood should be coated with a paint composed of white lead and linseed oil, or a mixture of one-third creosote and two-thirds coal tar, using the cheaper grades of these ingredients, may be applied immediately. If the mixture of creosote and coal tar is used it is not necessary to treat the wound with the mercuric-chlorid solution.

The removal of all infected fruit during the growing season is of great importance in preventing the spread of apple bitter-rot, especially when the first application of spray has been made too late or when it appears that the disease is about to gain a foothold early in the season. Of course, this is only practicable at the time the disease first appears and when comparatively few fruits have rotted. At that time it is usually practicable to remove the few infected fruits and to locate and remove many of the overwintering sources of infection overlooked during the dormant season, since the fruits below such sources are the first to be infected. Later, of course, such clumps of infected fruits will not serve as indicators of the location of overwintering sources of bitter-rot, since the infected fruits themselves serve to spread the disease and thus become sources of infection. When the removal of the first infected fruits and corresponding overwintering sources of infection is practiced, a thorough application of Bordeaux mixture should be made directly afterwards. In this way the writers have checked effectually at a nominal cost threatening outbreaks of this disease, in one case the expense of so treating 300 twenty-year-old trees being only $10 in addition to the usual cost of spraying.

All the methods of control herein outlined have been used successfully by the writers and by growers. The sanitation methods recommended are especially adapted to and practicable in the apple-growing sections of northern Arkansas, southern Missouri, and southern Illinois. In three years' time the writers, with the grower's aid, nearly eradicated the disease from one of the worst infested orchards in the United States and had it under control during the very first year.

DIRECTIONS FOR MAKING BORDEAUX MIXTURE.

Bordeaux mixture for use in bitter-rot control should contain ordinarily 4 pounds of bluestone (copper sulphate) and 4 pounds of quicklime to each 50 gallons of water. In orchards in which the disease has not been very serious in previous years, the quantity of bluestone may be reduced to 3 pounds. If the lime used is of poor quality and does not slake readily, 5 or 6 pounds of lime should be used.

To make a single barrel (50 gallons) of Bordeaux mixture, dissolve the bluestone in 25 gallons of water, and in a separate barrel slake the lime and dilute it to 25 gallons. Then pour the contents of the two barrels simultaneously through a strainer into the spray tank.

If large quantities are to be used, a stock solution of the bluestone and a stock milk of lime should be prepared, in order to save time.

A stock solution of bluestone may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water and place a sack (or a box with perforations in the bottom and sides) containing 50 pounds of bluestone in the upper part of the barrel, suspending it by a string or copper wire. In from 12 to 24 hours the bluestone will have entirely dissolved, when the sack or box should be removed and enough water added to fill the barrel. After stirring, the solution is ready for use.

The stock milk of lime may be prepared by slaking 50 pounds of stone lime in a barrel or other vessel and finally adding water to make 50 gallons. In slaking the lime, sufficient water should be used to prevent burning but not enough to "drown" it, and the mass should be continually stirred with a shovel or hoe until a thin paste is formed.

In making Bordeaux mixture, take the necessary quantities of the stock copper-sulphate solution and the stock milk of lime and place them in separate elevated dilution tanks, each of which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons, each dilution tank should hold 100 gallons, and, according to the above formula, 16 pounds of copper sulphate (16 gallons of the stock solution) and 20 pounds of lime (20 gallons of stock milk of lime) would be required. To each dilution tank add water (nearly one-half the total amount of spray), and, after stirring, allow the diluted ingredients to run through separate hose or troughs attached to faucets near the bottom of each tank into the strainer on the spray tank, where the two fluids coming together produce the Bordeaux mixture. Only the quantity which can be used during a single day should be prepared, as the mixture deteriorates on standing.

In case dilution tanks are not at hand, a good Bordeaux mixture can be conveniently made without them, provided a power sprayer

with a good agitator be used. Simply fill the tank with water until there is room only for the required quantities of the stock fluids. Then starting the engine (and accordingly the agitator), slowly add one stock fluid and then the other. For example, if the tank holds 200 gallons, fill with water to about the 160-gallon mark and then, starting the engine, slowly add the 16 gallons of stock bluestone solution and afterwards the 16 gallons of stock milk of lime; or the milk of lime may be added first. Allow the engine to run for a few minutes after both fluids have been added. Add more water if necessary to fill the tank. By this method an elevated platform is not needed, especially if an efficient mechanical tank filler is at hand.

When arsenicals or other insecticides are to be used with Bordeaux mixture, allowance should be made for these by leaving out the corresponding quantity of water from the quantities specified above.

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